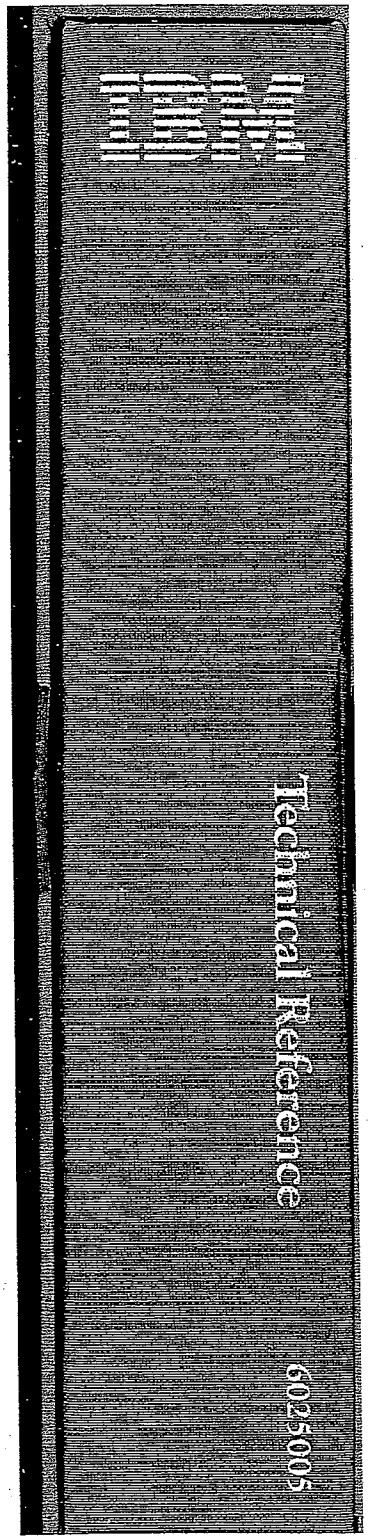
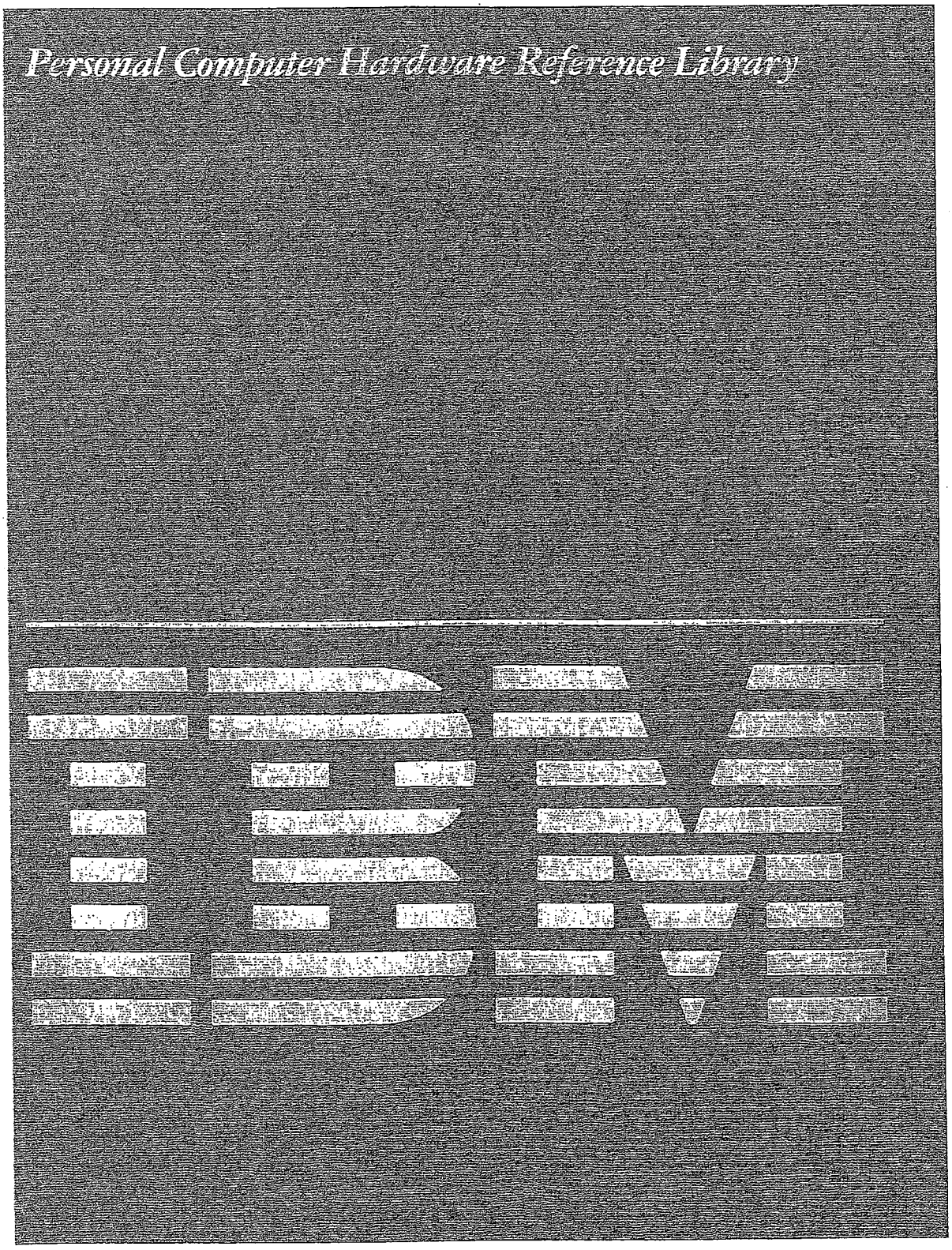
EXHIBIT 6
(PART 1 OF 2)


Technical Reference
6025005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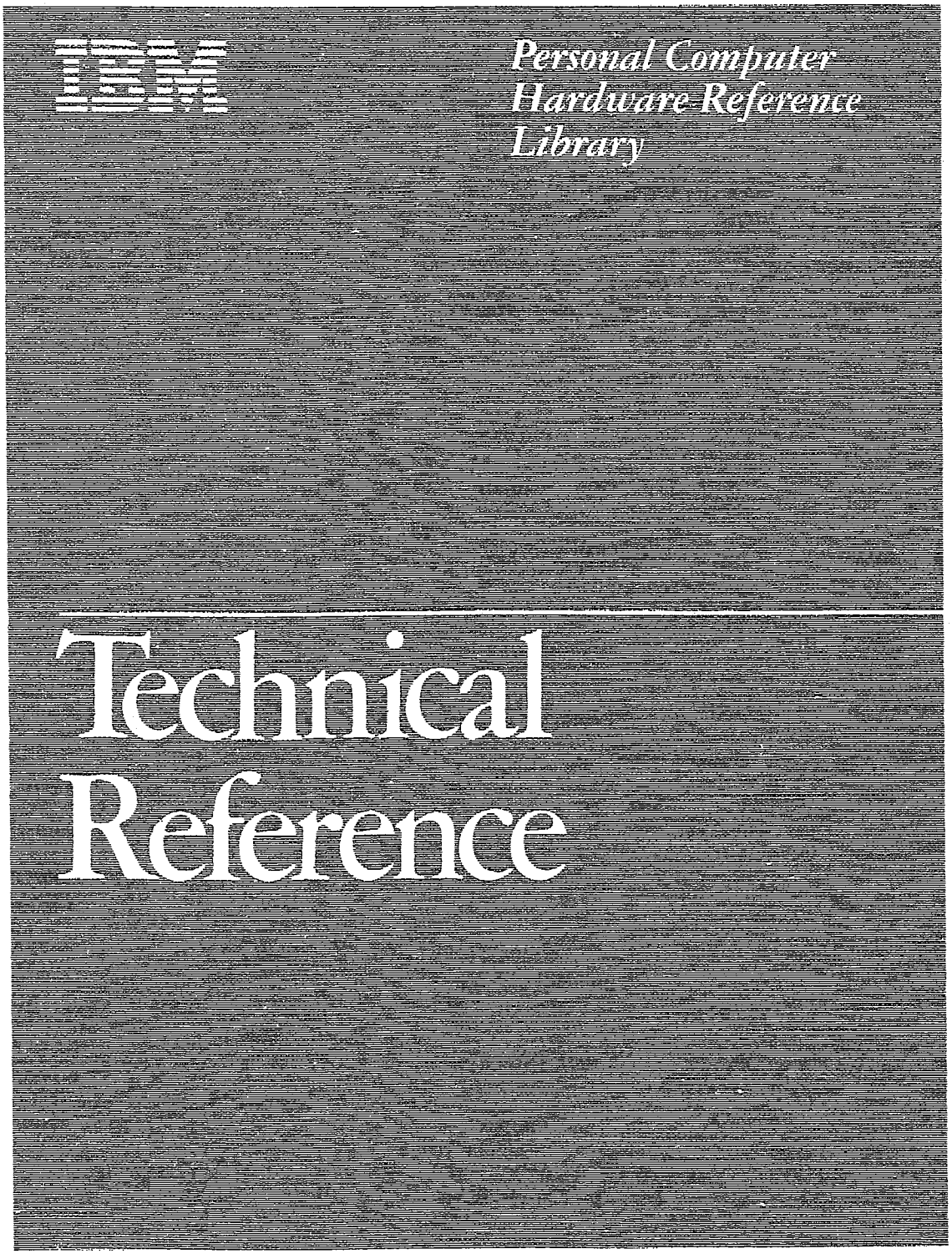
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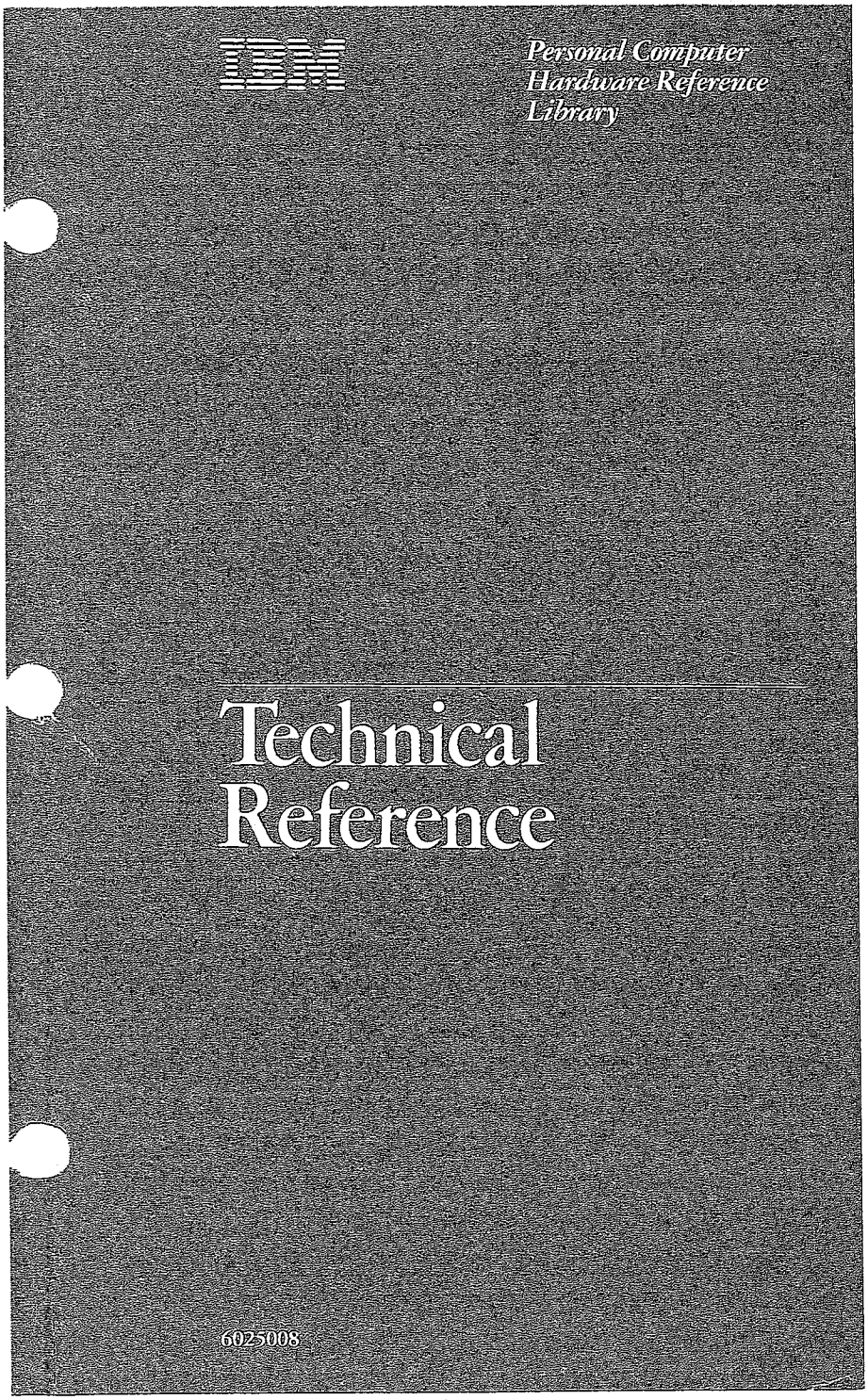
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Notice: As sold by the manufacturer, the Prototype card does not require certification under the FCC's rules for Class B devices. The user is responsible for any interference to radio or TV reception which may be caused by a user — modified prototype card.

Revised Edition (July 1982)

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PREFACE

The IBM Personal Computer Technical Reference Manual is designed to provide hardware design and interface information. This publication also provides Basic Input Output System (BIOS) information as well as programming support matter.

This manual is intended for programmers, engineers involved in hardware and software design, designers, and interested persons who have a need to know how the IBM Personal Computer is designed and works.

This manual has three sections:

Section - 1

"HARDWARE OVERVIEW," features an overview of the system as a whole calling out specific items such as the System Unit, Keyboard, IBM Monochrome Display and the 80 CPS Matrix Printer.

Section - 2

"HARDWARE," contains a description for each functional part of the system. This section also contains specifications for power, timing, and interface. Programming considerations are supported by coding tables, command codes and registers.

Section - 3

"ROM and SYSTEM USAGE," describes BIOS as well as how to use BIOS, interrupt vector listings, memory map, vectors with special meanings, a cassette section, a keyboard encoding section, and a set of Low Memory Maps.

"APPENDICES," to address the ROM BIOS listing, an instruction set, logic diagrams, and expanded charts used to support specific hardware descriptions.

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Color/Graphics Monitor Adapter

The Color/Graphics Monitor Adapter is designed to attach a wide variety of TV frequency monitors and TV sets (user-supplied RF modulator required for TVs). It is capable of operating in black and white or color, and provides three video interfaces; a composite video port, a direct drive port, and connection interface for driving a user supplied RF modulator. In addition, a light pen interface is provided.

The adapter has two basic modes of operation; alphanumeric (A/N) and all points addressable graphics (APA). Additional modes are available within A/N and APA modes. In A/N mode, the display can be operated in a 40x25 mode for low resolution monitor and TVs or 80x25 mode for high resolution monitors. In both modes, characters are defined in an 8x8 box and are 5x7 with one line of descender for lowercase (both uppercase and lowercase characters are supported in all modes). In black and white mode, the character attributes of Reverse Video, Blinking and Highlighting are available. In color mode, there are 16 foreground colors and 8 background colors available per character. In addition, blinking on a per character basis is available.

The adapter card contains 16KB of storage; thus, for a 40x25 screen, 1000 bytes are used to store character information and 1000 bytes are used for attribute/color information. This means that up to 8 pages of screens can be stored in the adapter memory. Similarly, in an 80x25 mode, 4 pages of display screen may be stored in the adapter. The full 16KB storage on the display adapter is directly addressable by the processor allowing maximum software flexibility in managing the screen. In A/N color modes, it is also possible to select the screen border color. One of 16 colors may be selected.

In APA mode, there are two resolutions available; 320x200 and 640x200. In the 320x200, each (picture element) pel may have one of four colors. The background color (color 0) may be any of the 16 possible colors. The remaining 3 colors come from one of the two software selectable palettes. One palette contains red/green/brown, the other contains cyan/magenta/white.

The 640x200 mode is only available in black and white since the full 16KB of storage is used to define the on or off state of the pel.

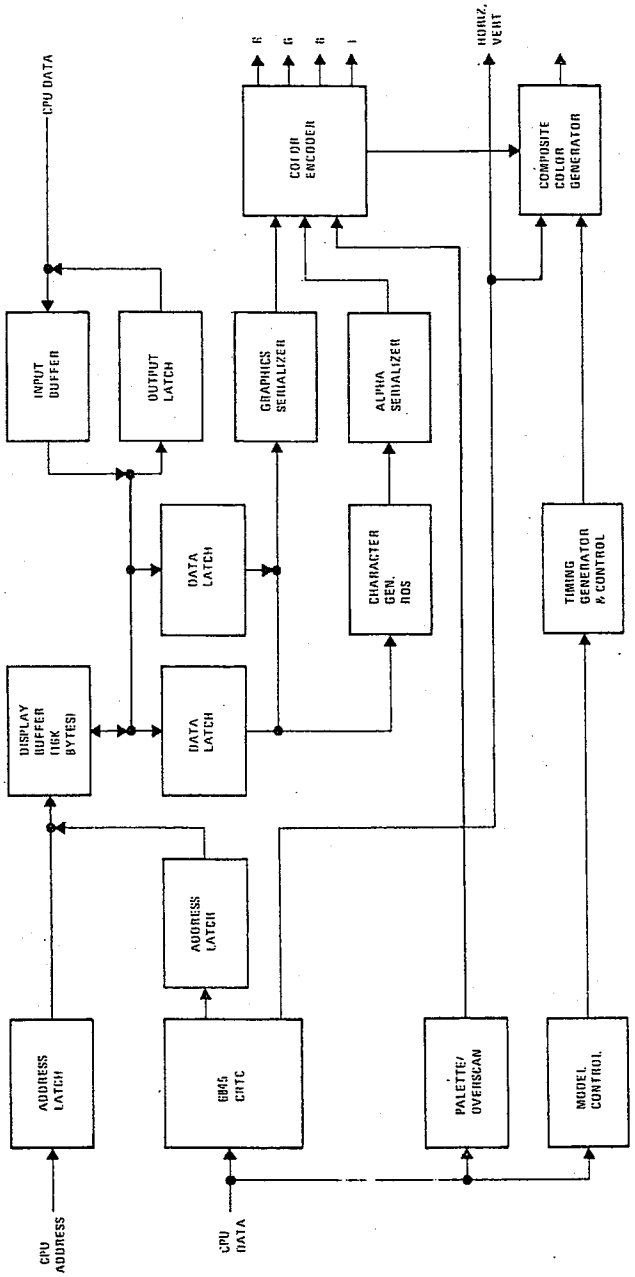
The adapter operates in noninterlace mode at either 7 or 14 megahertz (Mhz) video bandwidth depending on the mode of operation selected.

In A/N mode, characters are formed from a ROM character generator. The character generator contains dot patterns for 256 characters. The character set contains the following major grouping of characters. Sixteen special characters for game support, 15 characters for support of word processing editing functions, the standard 96 ASCII graphic set, 48 characters to support foreign languages, 48 characters for business block graphics allowing drawing of charts, boxes and tables using single and double lines, 16 of the most often used Greek characters, and 15 of the most often used scientific notation characters.

The Color/Graphics Monitor Adapter function is packaged on a single card which fits into one of the five System Expansions Slots on the System Board. The direct drive and composite video ports are right-angle mounted connectors at the rear of the adapter and extend through the rear panel of the System Unit.

The display adapter is implemented using a Motorola 6845 CRT controller device. This adapter is highly programmable with respect to raster and character parameters. Thus, many additional modes are possible with clever programming of the adapter. A block diagram of the Color/Graphics Adapter is on the following page.

Color/Graphics Monitor Adapter Block Diagram



HARDWARE

Figure 15. COLOR/GRAPHICS MONITOR ADAPTER BLOCK DIAGRAM

Major Components Definitions

Motorola 6845 CRT Controller

This device provides the necessary interface to drive a raster scan CRT.

Mode Set And Status Registers

This is a general purpose programmable I/O register. It has I/O points which may be individually programmed. Its function in this attachment is to provide mode selection (page 2-49 and 2-50) and color selection in the medium resolution color graphics mode (page 2-51.)

Display Buffer

The Display Buffer resides in the CPU address space starting at address X'B8000'. It provides 16K bytes of dynamic read/write memory. A dual-ported implementation allows the CPU and the graphics control unit to access this buffer. The CPU and the CRT control unit have equal access to this buffer during all modes of operation except in high resolution alphanumeric mode. In this mode the CPU should access this buffer during the horizontal retrace intervals. The CPU may however, write to the required buffer at any time, but a small amount of display fetches will result if not during retrace intervals.

Character Generator

This attachment utilizes a ROM character generator. It consists of 8K bytes of storage which cannot be read/written under software control. This is a general purpose ROM character generator with three different character fonts. Two character fonts are used on this card (a 7x7 double dot and 5x7 single dot), selected by a card jumper. No jumper gives a 7x7 double dot, with a jumper a single dot font is selected.

Timing Generator

This block generates the timing signals used by the 6845 CRT controller and by the dynamic memory. It also resolves the CPU/ graphic controller contentions for accessing the Display Buffer.

Composite Color Generator

The logic in this block generates base band video color information.

Modes of Operation

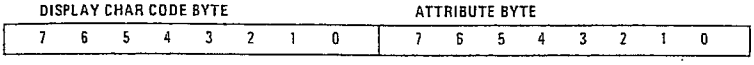
There are two basic modes of operation, 'Alphanumeric' and 'Graphics'. Each of these modes provide further options in both color and black-and-white. The following text describes each mode of operation.

Alphanumeric Mode

HARDWARE

Alphanumeric Display Architecture

Every display character position is defined by two bytes in the regen buffer (part of display adapter, not system memory). Both the color and the black and white display adapter use this 2 byte character/attribute format.



Attribute Byte Definition

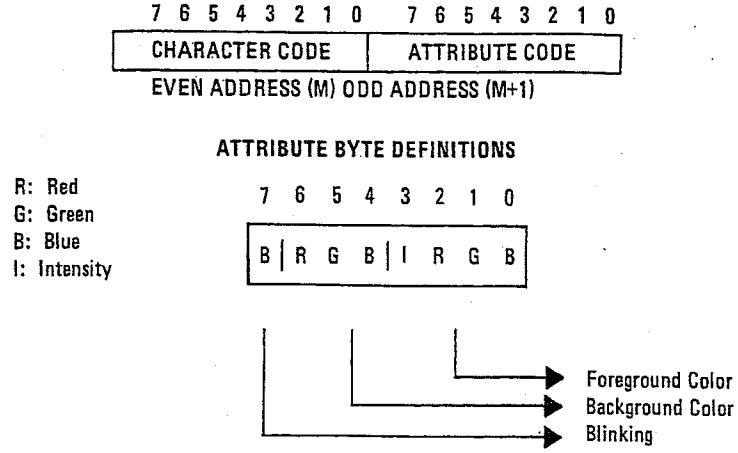
ATTRIBUTE BYTE

ATTRIBUTE FUNCTION	7	6	5	4	3	2	1	0
	B	R	G	B	I	R	G	B
	FG	BACKGROUND			FOREGROUND			
NORMAL	B	0	0	0	I	1	1	1
REVERSE VIDEO	B	1	1	1	I	0	0	0
NON DISPLAY (BLK)	B	0	0	0	I	0	0	0
NON DISPLAY (WHITE)	B	1	1	1	I	1	1	1

I = HIGH LIGHT FOREGROUND (CHAR)
B= BLINK FOREGROUND (CHAR)

Color TV

- Display up to 25 rows of 40 characters each
- Maximum of 256 characters
- Requires 2000 bytes of Read/Write Memory (on the adapter)
- 8x8 character box
- 7x7 double dotted characters (one descender)
- Character attributes (one for each character)



Note: The starting address of the display buffer must be an even location.

Color Monitor (with Direct Drive input capability)

Display up to 25 rows of 80 characters each

Requires 4000 bytes of Read/Write Memory (on the adapter)

Maximum of 256 character set

8x8 character box

7x7 character with one descender

Same format for attributes as for color TV

Note: The starting address of the display buffer must be an even location.

IBM Monochrome Display Adapter Vs. Color/ Graphics Adapter Attribute Relationship

Table 3. Monochrome Vs Color/Graphics Attributes

	7	6	5	4	3	2	1	0	ON THE MONOCHROME DISPLAY ADAPTER		ON THE COLOR/GRAPHIC DISPLAY ADAPTER	
	B	R	G	B	I	R	G	B	CHAR. COLOR	BKGD. COLOR	CHAR. COLOR	BKGD. COLOR
	FG	BACKGROUND			FOREGROUND							
NORMAL	B	0	0	0	I	1	1	1	WHITE	BLACK	WHITE	BLACK
RVV	B	1	1	1	I	0	0	0	BLACK	WHITE	BLACK	WHITE
NON DISP (BLK)	B	0	0	0	I	0	0	0	BLACK	BLACK	BLACK	BLACK
NON DISP (WHT)	B	1	1	1	I	1	1	1	WHITE	WHITE	WHITE	WHITE

ALL OTHER CODES DEFINE FOREGROUND BACKGROUND COLOR COMBINATIONS

ALL OTHER CODES RESULT IN WHITE CHAR ON BLACK BACKGROUND

ALL OTHER CODES CHANGE FOREGROUND BACKGROUND COLOR TO SELECTED VALUE

HARDWARE

R	G	B	
0	0	0	= BLACK
0	0	1	= BLUE
0	1	0	= GREEN
0	1	1	= CYAN
1	0	0	= RED
1	0	1	= MAGENTA
1	1	0	= YELLOW
1	1	1	= WHITE

CODE WRITTEN WITH AN UNDERLINE ATTRIBUTE FOR THE IBM MONOCHROME DISPLAY WHEN EXECUTED ON A COLOR/GRAPHICS ADAPTER WILL RESULT IN A BLUE CHARACTER WHERE THE UNDERLINE ATTRIBUTES ARE ENCOUNTERED.

CODE WRITTEN ON A COLOR/GRAPHICS ADAPTER WITH BLUE CHARACTERS, WILL BE DISPLAYED AS WHITE CHARACTERS ON BLACK BACKGROUND WITH A WHITE UNDERLINE ON THE MONOCHROME DISPLAY

* AN ADDITIONAL 8 COLOR (ACTUAL) DIFFERENT SHADES OF THE ABOVE) ARE SELECTED BY SETTING THE (I) BIT

Note: Not all Monitors Recognize the (1) Bit

Table 4. Color/Graphics Modes

	HORIZONTAL	VERTICAL	NO OF COLORS (INCL. BACKGROUND COLOR)
LOW RES	160	100	16 (INCLUDES BLACK AND WHITE)
MED RES	320	200	4 COLORS: 1 OF 16 FOR BACKGROUND PLUS GREEN, RED, YELLOW OR CYAN, MAGENTA, WHITE
HIGH RES	640	200	B & W ONLY

1. Low resolution color graphics (TV or monitor). (Note: This mode is not supported in ROM).
   - Up to 100 rows of 160 pels each (2x2)
   - 1 of 16 colors each pel specified by I, R, G and B
   - Requires 8000 byte of Read/Write Memory (on the adapter)
   - Memory mapped graphics (requires special memory map and set up to be defined later)
2. Medium resolution color graphics (TV or monitor)
   - Up to 200 rows of 320 pels each (1x1)
   - 1 out of 4 preselected colors in each box
   - Requires 16000 bytes of Read/Write Memory (on the adapter)
   - Memory mapped graphics

     4 pels/byte

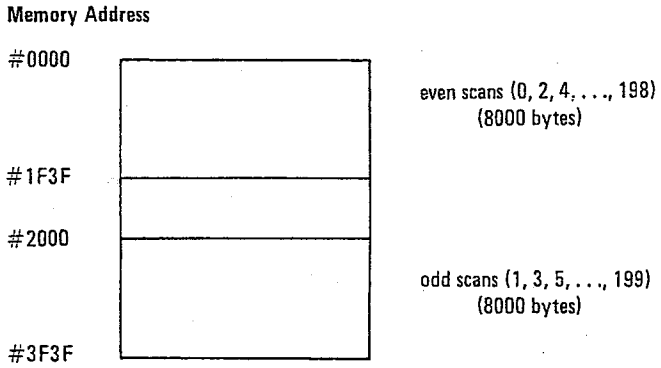
FORMAT:

7	6	5	4	3	2	1	0
C1	C0	C1	C0	C1	C0	C1	C0

First display pel

- Graphics storage is organized in two banks of 8000 bytes each.

Graphics Storage Map



Address #0000 contains pel information for upper left corner of display area.

Color selection is determined by the following logic:

C1 and C0 will select 4 of 16 preselected colors.

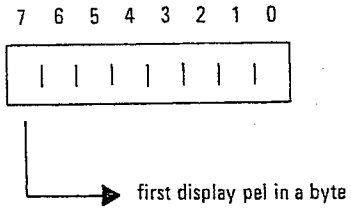
This color selection (palette) is preloaded in an I/O port.

C1	C0	CODE SELECT COLOR FOR DISPLAY POSITION
0	0	DOT TAKES ON COLOR OF 1 OF 16 PRESELECTED BACKGROUND COLORS.
0	1	SELECT 1ST COLOR OF PRESELECT COLOR SET "1" OR "2"
1	0	SELECT 2ND COLOR OF PRESELECT COLOR SET "1" OR "2"
1	1	SELECT 3RD COLOR OF PRESELECT COLOR SET "1" OR "2"

HARDWARE

The two color sets are:

SET ONE	SET TWO
COLOR 1 - CYAN	COLOR 1 - GREEN
COLOR 2 - MAGENTA	COLOR 2 - RED
COLOR 3 - WHITE	COLOR 3- BROWN

The background colors are the same basic 8 color as defined for low resolution graphic plus 8 alternate intensities defined by the intensity bit for a total of 16 color including black and white.

3. Black and white high resolution graphics (monitor)
   - Up to 200 rows of 640 pels each (1x1)
   - Black and white only
   - Requires 16000 bytes of Read/Write Memory (on the adapter)
   - Addressing and mapping is the same as for medium resolution color graphics, but the data format is different. In this mode each bit in memory is mapped to a pel on the screen.
   - 8 pels/byte